



ANALOG DEVICES

221 FIFTH STREET, CAMBRIDGE, MASSACHUSETTS 02142

NEW
ACTIVE FILTER CAT

Mr. T. Nelson dg 07870zzzznelst0
Sys Cons
Box 3
Schooleys Mountain, New Jersey 07870

USE THIS REPLY CARD FOR SERVICE

JUST COMPLETE ITEMS OF INTEREST, FOLD TWICE, STAPLE, AND MAIL POSTPAID

☐ I AM INTERESTED IN THE FOLLOWING ACTIVE FILTER APPLICATION:

We can best assist you if you will indicate as much detail as possible about the application you have in mind. Use whatever items are appropriate to the type of filter in question. Indicate in the Comments section your application objectives (e.g., very sharp cutoff, linear phase, smooth transient response, etc.) and the use of the filter in the equipment.

ACTIVE FILTER REQUIREMENTS

MODEL	LOW PASS ☐ BAND PASS ☐		
	HIGH PASS ☐ BAND REJ. ☐		
FREQUENCY CHARACTERISTICS	UNITS	SPECIFICATION	COMMENT
Cutoff (f_c) or Center (f_o) Freq	Hz		
Tolerance	Δ Hz		
No. of Poles	1-8		
Stability vs. Temp.	%/ $^{\circ}$ C		
Source Resistance	Ω		
PASSBAND GAIN ($\pm$ Tol.)	dB		
Freq. for Gain Tol.			
Low Pass, min	Hz		
High Pass, max	Hz		
Band Pass, or Band Reject	Hz		
NOTCH, Attenuation @ f_o (min)	dB		
SELECTIVITY, Q ($\pm$ Tol.)			
ACTIVE CHARACTERISTICS			
INPUT (Non-Inverting/Inverting)	+ or -		
Input Impedance, min	Ω		
Input Voltage Range, min	Volts		
Input Bias Current, max	μ A		
OUTPUT			
Rated Output @ Ω	Volts		
Full Power Response, min	Hz		
Output Noise (rms or p-p)	Volts		
Output Resistance	Ω		
Offset Voltage @ 25 $^{\circ}$ C	mV		
Offset vs. Temp.	μ V/ $^{\circ}$ C		
POWER SUPPLY (DC)			
Voltage, Rated Specs	Volts		
Voltage, Operating Specs	Volts		
Current, Quiescent	mA		
CASE CONFIGURATION (LxWxH)	in.		
TEMP. RANGE	$^{\circ}$ C		

KEY APPLICATION FEATURE:

Overshoot ☐ Sharp Roll-off ☐ Wide Signal Range ☐
Flat Passband ☐ Linear Phase ☐ Temp. Stable Freq. ☐
Matched Filters ☐

Additional notes and comments

Frequency response similar to type _____ (if any)

SKETCH
TYPE
OF FILTER
HERE

$f_c =$ _____

My application is ☐ 3-6 mos
☐ Immediate ☐ Info only
☐ Please have engineer phone me
_____ area code _____ phone number _____ ext
☐ I would like a price quotation on _____ units.
☐ I would like a "loaner" to evaluate
☐ Please place me on special mailing list to receive active filter information
☐ I am also interested in power amplifiers

Mr. T. Nelson
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Schoolleys Mountain, New Jersey 07870

dg 07870zzzznelst0

☐ Please correct my address as follows:

☐ Please add the following to ☐ filter ☐ general mailing list

☐ Please remove duplicates from Analog's mailing list. Duplicate labels are attached



INSTANT ACTION REQUEST

POSTAGE PAID

USE REVERSE SIDE OF THIS CARD FOR SERVICE

BUSINESS REPLY MAIL

No postage stamp necessary if mailed in the United States

FIRST CLASS MAIL
Permit No. 39342
Cambridge, Mass.

POSTAGE WILL BE PAID BY:



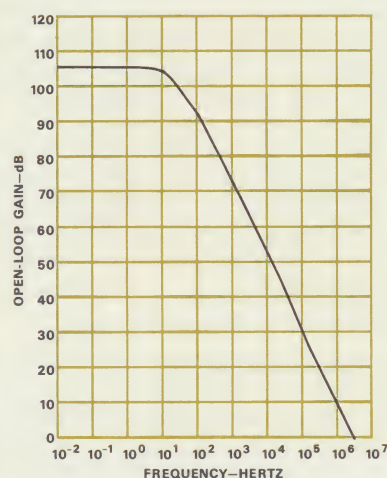
221 Fifth Street, Cambridge, Mass. 02142



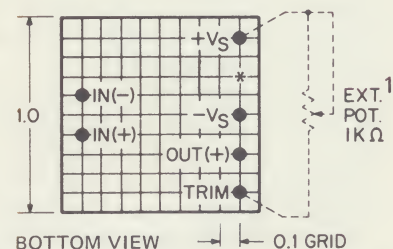
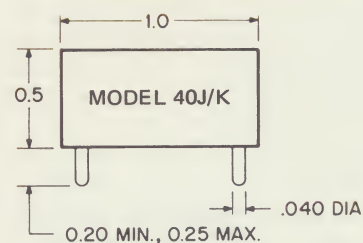
MODEL	40J	40K
OPEN LOOP GAIN		
dc rated load, min	5x10 ⁴	*
dc 10k load	2x10 ⁵	*
RATED OUTPUT		
Voltage, min	±10V	*
Current, min	±5mA	*
Load capacitance range	0.005μF	*
FREQUENCY RESPONSE		
Unity gain, small signal	4MHz	*
Full power response, min	100kHz	*
Slewing rate, min	6V/μsec	*
Overload recovery	4μsec	*
INPUT OFFSET VOLTAGE		
External trim pot	1kΩ ¹	*
Initial offset, 25°C	±2mV(500Ωtrim)	*
Avg. vs. temp (+10° to +60°C) max	±50μV/°C ³	±20μV/°C
vs. supply voltage	±50μV/%	*
vs. time	±250μV/month	*
INPUT BIAS CURRENT		
Input bias, 25°C, max	(0,-) 50pA	(0,-) 20pA
Avg. vs. temp	doubles every +10°C	*
vs. supply voltage	±1 pA/%	*
INPUT DIFFERENCE CURRENT		
Initial difference, 25°C	±25pA	±10pA
Avg. vs. temp	doubles every +10°C	*
INPUT IMPEDANCE		
Differential	10 ¹¹ Ω 3.5pF	*
Common mode	10 ¹¹ Ω 3.5pF	*
INPUT NOISE		
Voltage, 0.01 to 1Hz, p-p	6μV	*
5 to 50kHz, rms	3μV	*
Current, 0.01 to 1Hz, p-p	0.1pA	*
INPUT VOLTAGE RANGE		
Common mode voltage, min ² (1% error)	+8, -10V	*
Common mode rejection ² @+8, -10V	80dB	*
Max. safe differential voltage	±15V	*
POWER SUPPLY		
Voltage, rated specification	±15V	*
Voltage, derated specification	±(12 to 18)V	*
Current, quiescent	5.5mA	*
TEMPERATURE RANGE		
Rated performance	+10° to +60°C.	*
Operating	-25° to +85°C	*
Storage	-55° to +125°C	*
MECHANICAL		
Case style - pin configuration	M-2	*
Mating socket	AC 1003	*
Weight	0.52 oz.	*
PRICE		
1-9	\$12.00	\$19.00
10-24	\$11.80	\$17.10

*Specifications same as for Model 40J.
 1 Analog Devices part no. 79PR 1K \$3.00 (1-9)
 2 CMRR of 74dB min @ $\pm 10V$, specify model 40JV, \$3.00 additional (1-24)
 3 Same specification available $-25^{\circ}C$ to $+85^{\circ}C$. Consult factory or your nearest Analog representative about Model 40A.
 Specifications subject to change without notice.

OPEN LOOP FREQUENCY RESPONSE



OUTLINE DIMENSIONS

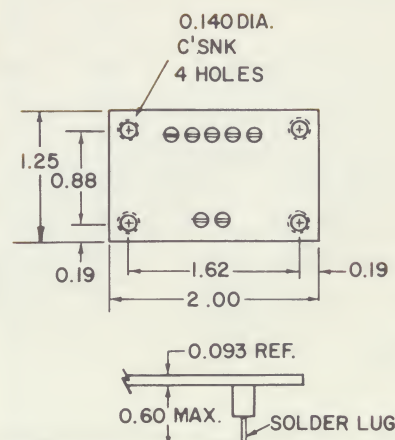


*Note: Common supply connection not necessary within the amplifier.

¹ External variable resistor is used to zero the amplifier. Fixed 500-ohm resistor gives nominal zero (± 2 mV). If no resistor desired, connect TRIM to V_s . If TRIM left open, unit operates, but with considerable offset.

MATING SOCKET
AC 1003

PRICE (1-9) \$2.75



DESCRIPTION

Model 40J was designed to fill the need for a low-cost general-purpose differential FET-input operational amplifier with a minimum of performance compromises. As will be seen in the table below, it turns out to be a "Best Buy" when its salient specifications are compared with those of two competitive discrete FET-input op amps, a "super-beta" I.C., and the 118A, a general-purpose bipolar-input modular operational amplifier.

Because of its low cost, Model 40J is a natural first choice for applications requiring FET-input amplifiers, or where marginal bias current specifications of available low-cost bipolars have in the past led to performance compromises for the sake of cost. This new low cost even makes it feasible to think in terms of stocking Model 40J, and buying bipolar-input types only for those exceptional cases where their characteristics are entirely adequate.

Where higher performance is required, Model 40K provides 20 pA of bias current and $20\mu\text{V}/^\circ\text{C}$ drift at only \$19.00 (1-9). For even more demanding applications, Analog Devices offers a broad line of FET op amps offering tighter specifications on key parameters. Examples are: Low voltage drift $2\mu\text{V}/^\circ\text{C}$ (Model 146), high common-mode rejection 40,000 (Model 143), ultra-fast response 0.8 and $1.5\mu\text{s}$ to 0.01% (Models 45 & 149), and miniature hybrid TO-8 construction (Model M501).

WHERE TO USE MODEL 40

FET op amps are usually the best choice when the amplifier's signal input comes from a high-impedance source (such as a photomultiplier), where extremely high input impedance is desired to minimize loading of a signal source (for example, measuring voltage across an unknown impedance), or for the measurement of very small currents. The benefits of FET op amps in these applications are manifest in two ways:

1. Input impedances are high. High input impedance is especially useful in such non-inverting applications as buffer amplifiers and moderate speed sample-holds, and in inverting applications requiring large values of feedback resistance, including integrators and differentiators for slowly-varying signals.

2. Bias currents are low. (Bias currents are the small leakage currents which flow through the input terminals). This allows accurate measurement of small currents, and also reduces that component of output voltage drift due to the voltage drop of bias current in feedback circuit resistors. It also allows the design of integrator circuits having low drifts and sample-hold circuits with excellent ability to retain charge. For example, in an integrator application at room temperature, employing Model 40J, the rate of leakage across a $1.0\mu\text{F}$ capacitor in HOLD will be less than $50 \times 10^{-12} / (1.0 \times 10^{-6}) = 50\mu\text{V}$ per second. That capacitor, if charged to +10V, would lose less than 0.1% of its charge (i.e., 10mV) in 200 seconds (assuming that the capacitor's own time constant were greater than 0.2 million seconds, circuit leakage resistance were better than $200\text{ k}\Omega$, etc.).

SALIENT SPECIFICATIONS OF TYPICAL ALTERNATIVES

		40J	3308/12C*	QFT-5*	LM208*	118A
A_o , min, 10k load	V/V	200k typ.	200k no load	75k	50k	250k rated load
f_p , min.	kHz	100	100	50	2	100 (INV)
Output, rated	V@mA	$\pm 10 @ \pm 5$	$\pm 10 @ \pm 5$	$\pm 10 @ \pm 5$	$\pm 10 @ \pm 2$	$\pm 10 @ \pm 5$
$\Delta E_{os}/\Delta T$, max,	$\mu\text{V}/^\circ\text{C}$	± 50	± 50	± 300	± 15	± 20
I_b , max, 25°C ,	pA	-50	-100	-100	3nA	+35nA
R_{in} , differential	ohms	10^{11}	10^{11}	10^{10}	7×10^7	10^6
Price (1-9) U.S. Dol.		\$12.00	\$11.90	\$12.00	\$40.00	\$11.00

*Published specifications available November, 1969

MODEL 40J/K GENERAL PURPOSE LOW COST FET OP-AMP

FEATURES

Voltage Drift	$\pm 50\mu\text{V}/^\circ\text{C}$ max
Bias Current	50pA max
Bandwidth	4MHz
Slew Rate	$6\text{V}/\mu\text{sec}$
Low Noise	3 μV rms
Low Cost (1-9)	\$12.00 (40J)



APPLICATIONS

High Impedance Buffer Amplifiers
Precision Integrators
Sample-and-Hold Circuits
Picoamp Current Measurements



221 FIFTH ST., CAMBRIDGE, MASS. 02142
TEL: 617/492-6000 TWX: 710/320-0326



ANALOG UPDATE

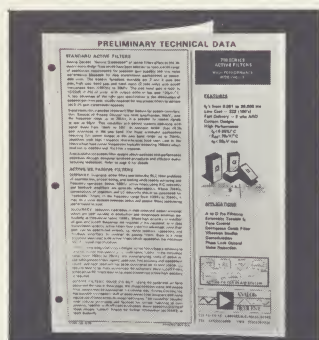
NEWS OF NEW PRODUCTS FROM ANALOG DEVICES

PUBLISHED BY ANALOG DEVICES, INC. • CAMBRIDGE • MASSACHUSETTS 02142 • JUNE 1, 1970

ACTIVE FILTERS FROM ANALOG DEVICES

700 SERIES ACTIVE FILTERS

Enclosed is a brochure describing a new, comprehensive series of Active Filters available from Analog Devices. These filters include all the popular types (high pass, low pass, bandpass, band reject), pole-pair configurations (Butterworth, Tchebyscheff, Bessel, Paynter) and characteristic frequency ranges (0.001Hz to 20kHz).



Constructed with low-cost high-performance IC's, according to designs optimized by novel computer programs, and packaged in miniature modular forms, they combine low price with a number of advanced performance features, such as low noise (hence wide dynamic range), low drift, high-accuracy transmission in the pass band, and accurately preset characteristic frequencies.

Furthermore, they are available in three classes having graded availability:

- Standard units, available from stock to 2 weeks
- "Standard Specials" i.e., designs producible in fairly short order and with *no* "startup" or one-time engineering charges.
- Custom units, designed to special order to meet the needs of specific OEM circuit, equipment, and system problems. Design and production delays are minimized by the availability of a comprehensive library of computerized filter design programs.

Finally, all of the above result in an unusually high ratio of performance to price. For example, \$22 (100's) will buy high- or low-pass 2-pole filters with cutoff frequencies in the range 10Hz to 20kHz, having ± 0.02 dB amplitude tolerance in the pass band, 2% f_c tolerance ($\pm 0.05\%/^{\circ}\text{C}$), full-power (f_p) response to 50kHz, 50 μV rms wideband noise, maximum $\pm 2\text{mV}$ offset ($\pm 20\mu\text{V}/^{\circ}\text{C}$), and 30k Ω input impedance. Similar user value is obtainable for more sophisticated performance, in both standard and special lines.

WHY ACTIVE FILTERS?

For many years, passive devices, composed of inductors and capacitors have been the major approach to signal filtering. However, they have had a number of weaknesses, including sensitivity to source and load impedances, impracticability at low frequencies, and a limited range of transfer functions. More

recently, *active filters*, utilizing operational amplifiers and resistors and capacitors have become available. These filters have been characterized by high input impedances, low output impedance (and insensitivity to loading), excellent performance at low frequencies (e.g., 0.001Hz), and the availability of a variety of transfer functions limited largely by the stability of feedback circuits.

MAKE OR BUY?

The increased availability of operational amplifiers and high-precision R's and C's, plus the unique nature of filter requirements (every filter user needs a set of characteristic frequencies peculiar to his application), plus a plethora of information on active filter design published widely in the technical press, seemingly makes it an easy matter for the design engineer to design and build filters for his own application. However, one must consider the costs of designing and building filters (including basic engineering, specifying the parts, delivery time, controlling many vendors, etc.) as compared with the variety of standard filters available from production at today's low prices. The decision of many engineers, for whom the filter is just an incidental (albeit important) building block in the system and subject to many of the same practical and economic considerations as other sophisticated building blocks (such as op amps, D/A Converters, multipliers, etc.), tends increasingly toward purchase of standard units from qualified vendors who can provide applications advice as well as low-cost reliable products.

WHY BUY FROM ANALOG?

Analog Devices, Inc., as an experienced manufacturer, supplier and *user* of op amps, multipliers, D/A Converters, etc., is now applying its engineering and production strength, and its philosophy of designing and pricing products for *greater user value*, to the manufacture of active filters having exacting specifications, at realistic prices. Both standard and custom filters are designed with the aid of computers, and they use (at our low cost) IC amplifiers selected from our product line and optimized for the job, as well as precision components purchased in extremely large volume.

ACTION

Read the brochure for complete details. Then if you'd like further information as to how Analog Devices active filters can help you with your filtering job, if you'd like to evaluate one of our filters, or if you'd like a price quotation, phone our nearest representative or sales office (see reverse side) or fill in and mail the enclosed postage paid Instant Action request. Or phone Pete Zicko collect on our "hot line," 617/492-6000.





ANALOG DEVICES, INC.

Representatives & Sales Offices In U.S.A. & Canada

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Hawaii	see Cambridge, Massachusetts		Ontario	1. (Eastern) Ottawa 2. (Western) Downsview	613/224-1221 TWX: 610/562-1920 416/247-7454 TWX: 610/492-2383 514/683-3621 TWX: 610/422-3980
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Utah	see Englewood, Colorado				
Vermont	see Cambridge, Massachusetts				

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STATE	COMPANY	ST. ADDRESS OR P.O. BOX
Alabama	Scientific Devices, S.E.	703 Watts Drive S.E.
Arizona	Klein Aerospace	1805 East Indian School Road
California	1. Analog Devices, Inc. 2. Analog Devices, Inc.	1 First St. 4004 Orange Avenue
Colorado	Klein Aerospace	P.O. Box 1056
Florida	Scientific Devices, S.E.	707 E. Colonial Dr.
Illinois	Data Electronics Co.	5505 N. Menard Ave.
Indiana	Data Electronics Co.	P.O. Box 50084
Kansas	Technical Sales Assoc.	5827 Outlook Rd. Suite 8
Maryland	Rep-Tron, Inc.	8525 Colesville Rd.
Massachusetts	Analog Devices, Inc. (Home Office)	221 Fifth St.
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Ontario	1. Whittaker Electronics Ltd. 2. Whittaker Electronics Ltd.	42 Howden Ave. 43 Troutbrook Dr.
Quebec	Whittaker Electronics Ltd.	P.O. Box 216

PRELIMINARY TECHNICAL DATA

STANDARD ACTIVE FILTERS

Analog Devices' "Second Generation" of active filters offers to the industry many design firsts which have been selected to meet a wide range of application requirements for excellent gain stability and low noise performance (desirable for data transmission applications) at reasonable costs. The transfer functions available are 2 and 4 pole low pass, high pass, band pass and band reject (2 pole only) with cutoff frequencies from 0.001Hz to 20kHz. The pass band gain is held to $\pm 0.02\text{dB}$ ($\pm 2\%$) of unity, with output drifts of less than $\pm 20\mu\text{V}/^\circ\text{C}$. A key advantage of the tight gain specification is the elimination of external gain trim pots, usually required for less precise filters to achieve the 0.2% gain transmission accuracy.

Signal resolution is another important filter feature for system consideration. Because of Analog Devices' low noise specification, $50\mu\text{V}$, over the frequency range up to 20kHz, it is possible to resolve signals as low as $50\mu\text{V}$. This capability will permit systems operating with signal levels from 10mV to 10V, to maintain better than $\pm 0.5\%$ gain accuracies in the pass band. For those wideband applications requiring full power output in the pass band range, up to 20kHz, amplifiers with high frequency characteristics have been used in the filters which have corner frequencies typically exceeding 100kHz which tend not to interfere with the filter's response.

Also available are custom filter designs which optimize cost-performance objectives through computer synthesis procedures and efficient manufacturing techniques. Refer to page 6 for details.

ACTIVE VS. PASSIVE FILTERS

SUMMARY: In general, active filters overcome the RLC filter problems of insertion loss, critical tuning, and loading while readily achieving low frequency operation. Below 100Hz, active filters using R-C networks and feedback amplifiers, are generally advantageous. Above 20kHz, combinations of amplifiers and LC networks should be considered for "realizable" filters. In the frequency range from 100Hz to 20kHz, it may be a close decision between active and passive filters considering performance vs. cost.

ACCURACY: Inductors have losses in their cores and copper windings which are both variable in production and temperature sensitive, particularly at frequencies below 100Hz. Where high accuracy or stability of gain and cutoff frequency are required in the passband, as in data transmission systems, active filters have a distinct advantage, since their gain can be determined entirely by stable resistors, capacitors, and feedback amplifiers. In contrast to passive filters, there is a noise threshold associated with active filters which establishes the minimum level for signal discrimination.

COST: Using integrated circuit designs, active filters have a tendency to be lower in cost than passive LC circuits below 100Hz. In the frequency range from 100Hz to 20kHz, the manufacturing costs of active vs. realizable passive filters depend upon specified accuracy and component count, and each approach has to be considered on its own merits. LC circuits tend to be more economical for extremely sharp cutoff filters, while active RC filters tend to be more economical where high accuracy is required.

ACTIVE FILTERS—MAKE OR BUY: Using the guidelines set forth above and the data in these pages, the choice between active and passive filter designs may be approached in a rational way. Analog Devices, Inc. has available a competent staff of experienced filter designers who make regular use of latest computer design techniques. This capability, coupled with volume purchasing and facilities for critical matching of components, together with efficient production, assure economic pricing of these designs. Consult Analog for further information on MAKE vs BUY tradeoffs.

700 SERIES ACTIVE FILTERS

HIGH PERFORMANCE
WIDE CHOICE

FEATURES

f_c 's from 0.001 to 20,000 Hz

Low Cost — \$22 (100's)

Fast Delivery — 2 wks ARO

Custom Designs

High Performance

$\Delta f_c < 0.05\%/^\circ\text{C}$

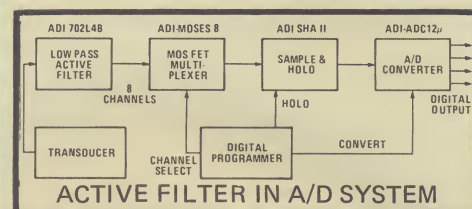
$\Delta E_{os} < 20\mu\text{V}/^\circ\text{C}$

$e_n < 50\mu\text{V rms}$



APPLICATIONS

A to D Pre-Filtering
Externally Tunable f_c
Tone Control
Contiguous Comb Filter
Vibration Studies
Demodulation
Phase Lock Control
Noise Reduction



221 FIFTH ST., CAMBRIDGE, MASS. 02142
TEL: 617/492-6000 TWX: 710/320-0326

700 SERIES—STANDARD ACTIVE FILTERS

INTRODUCTION

Analog Devices offers two standard series of active filters classified according to frequency. The first series is available with cutoff frequencies from 1Hz to 20kHz. The second series, with frequencies from .001Hz to 1Hz, is the industry's only standard ultra-low frequency series of active filters. Many of the specs described below are common to both series.

STANDARD RANGE: 1Hz to 20kHz

The standard frequency models, with nominal gain of 1 and characteristic frequencies from 1Hz to 20kHz, are available in a wide variety of transfer functions (low pass, high pass, band pass and band reject) and rolloff rates (two and four poles). They offer excellent characteristics for the majority of applications at reasonable prices. For accurate data transmission requirements, the pass band gain is held to within $\pm 0.02\text{dB}$ (0.2%) of unity with output drifts of less than $\pm 20\mu\text{V}/^\circ\text{C}$ and noise less than $50\mu\text{V}$ RMS (0 to 50kHz). Because of the tight 0.2% gain accuracy, the need for

external gain trim pots is eliminated for most designs. These filters have a full power response of 50kHz and will operate to 100kHz with less than 1% amplitude error.

ULTRA-LOW RANGE: 0.001Hz to 1Hz

For low frequency applications, Analog Devices offers a line of fully specified active filters in the range from 0.001 Hz to 1Hz. These sophisticated designs are available in Butterworth low pass and high pass configurations and feature 2 and 4 pole roll-offs. Band pass filters may be developed by cascading low pass and high pass filters. In addition to having the specifications of the STANDARD RANGE models, these filters are designed for low input bias currents of 10 pA and input impedances of one megohm. These characteristics are highly desirable for applications using low current transducers such as are commonly found in medical and geophysical applications and in spectrum analyzer equipment where input loading effects must be minimized for gain accuracy.

APPLICATION DETERMINES FILTER CHOICE

INTRODUCTION

This section, in conjunction with the frequency response curves on page 5, presents the key parameters which distinguish the various types of filters. The key parameters of interest are pass-band linearity (Butterworth), linear phase response and fast settling time (Bessel) and steepest roll-off (Tchebyscheff). Bandpass and Band reject responses are also discussed. Bessel and Tchebyscheff filters are available as Standard Specials. See page 6 for these, as well as custom filters.

HIGH PASS & LOW PASS

BUTTERWORTH — (Standard) Figs. 1A,B,C

The Butterworth transfer function provides a maximally flat amplitude response in the pass-band. Attenuation is -3dB at f_c and rolls off at -6dB per octave per pole beyond f_c . The step response displays moderate overshoot which increases with the number of poles, N . These are used where passband gain accuracy is important, as well as for general-purpose applications.

BESSEL — (Custom) Figs. 2A,B,C

The Bessel transfer function provides a constant time delay in the pass-band. The phase delay increases linearly from 0 to $N\pi/4$ radians and amplitude response is -3dB down at the cutoff frequency f_c . The fast settling time and absence of overshoot in the step response make them desirable for A/D & D/A systems.

Bessel filters are used in reconstruction of waveforms and direct frequency measurements. They also appear in averaging filters, voltage to frequency conversion and fixed time delay applications.

TCHEBYSCHIEFF — (Custom) Figs. 3A,B,C

The Tchebyscheff transfer function achieves a sharp frequency cutoff at the expense of allowing ripple in the pass-band. This filter may be chosen to achieve the sharpest amplitude rolloff per number of poles. Tchebyscheff filters are specified by the amount of pass-band amplitude ripple and the cutoff frequency, f_c , at -3dB attenuation.

Tchebyscheffs are used where rolloff rate is all-important and gain variations are of secondary consideration, such as audio applications.

BAND PASS & BAND REJECT

Figs. 4A,B,C

Band Pass filters pass signal frequencies in the pass band region and attenuate all other frequency components outside this region, which is defined by the upper and lower -3dB points of the response curve. These filters are specified by the center frequency, f_o , and the selectivity, $Q=(f_o/f_H-f_L)$, where f_H and f_L are the upper and lower -3dB attenuation frequencies. Also $f_o=\sqrt{f_H f_L}$, the geometric mean of the -3dB frequencies.

Band Reject filters are characterized by a center frequency, f_o , the selectivity, Q , and the notch attenuation. The response of the band reject filter attenuates signal frequencies in the center region, commonly referred to as the notch, and passes all other frequencies above and below the notch. The notch region is defined by the -3dB points on the response curve.

Band filters find wide applications in the areas of tone control, audio equalizers and contiguous comb filtering.

700 SERIES ACTIVE FILTERS

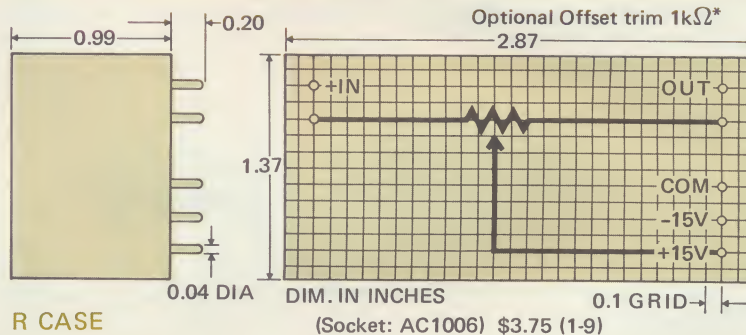
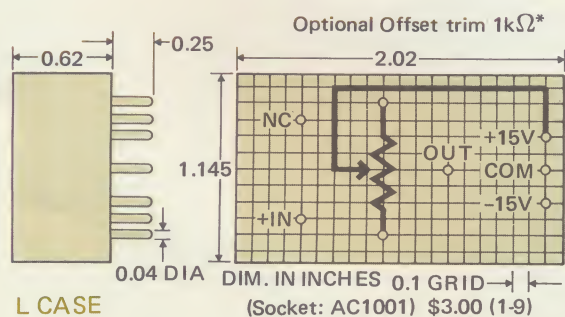
LOW PASS AND HIGH PASS RESPONSES

SPECIFICATIONS — (typical at 25°C unless otherwise noted)

FILTER TYPE		LOW PASS AND HIGH PASS BUTTERWORTH RESPONSE							
MODEL	LOW PASS	700L2B	700L4B	702L2B	703L4B	704L2B	705L4B	706L2B	707L4B
	HIGH PASS	701H2B	701H4B	708H2B	709H4B	710H2B	711H4B	712H2B	713H4B
CUTOFF FREQUENCY, f_c		ULTRA LOW RANGE				STANDARD RANGE			
Range		.001Hz to .1Hz		.1Hz to 1Hz		1Hz to 10Hz		10Hz to 20kHz	
Tolerance		±2%	±2%	±2%	±2%	±2%	±2%	±2%	±2%
No. of Poles		2	4	2	4	2	4	2	4
Stability vs. Temp. ¹		±.05%/°C	±.05%/°C	±.05%/°C	±.05%/°C	±.05%/°C	±.05%/°C	±.05%/°C	±.05%/°C
Source Resistance ²		20kΩ	20kΩ	20kΩ	20kΩ	600Ω	600Ω	600Ω	600Ω
PASSBAND GAIN		(0±.02)dB	(0±.02)dB	(0±.02)dB	(0±.02)dB	(0±.02)dB	(0±.02)dB	(0±.02)dB	(0±.02)dB
Freq. for ±.02dB Gain Tol.									
Low Pass, min		.15 f_c	.5 f_c	.15 f_c	.5 f_c	.15 f_c	.5 f_c	.15 f_c	.5 f_c
High Pass, max		7 f_c	2 f_c	7 f_c	2 f_c	7 f_c	2 f_c	7 f_c	2 f_c
ACTIVE CHARACTERISTICS									
INPUT (Non-Inverting)									
Input Impedance, min		1MΩ	1MΩ	1MΩ	1MΩ	30kΩ	30kΩ	30kΩ	30kΩ
Input Voltage Range, min		±10V	±10V	±10V	±10V	±10V	±10V	±10V	±10V
Input Bias Current, max		10pA	10pA	3nA	3nA	30nA	30nA	30nA	30nA
OUTPUT ⁴									
Rated Output @ 2mA		±10V	±10V	±10V	±10V	±10V	±10V	±10V	±10V
Full Power Response, min ⁶		50kHz	50kHz	50kHz	50kHz	50kHz	50kHz	50kHz	50kHz
Output Noise (RMS) ⁵		50μV	50μV	50μV	50μV	50μV	50μV	50μV	50μV
Output Resistance		1Ω	1Ω	1Ω	1Ω	1Ω	1Ω	1Ω	1Ω
Offset Voltage ³ @ 25°C		±2mV	±2mV	±2mV	±2mV	±2mV	±2mV	±2mV	±2mV
Offset vs. Temp. ¹		±25μV/°C	±40μV/°C	±25μV/°C	±40μV/°C	±20μV/°C	±30μV/°C	±20μV/°C	±30μV/°C
POWER SUPPLY (DC)									
Voltage, Rated Specs		±15V	±15V	±15V	±15V	±15V	±15V	±15V	±15V
Voltage, Operating, Specs		±10 to ±18V	±10 to ±18V	±10 to ±18V	±10 to ±18V	±10 to ±18V	±10 to ±18V	±10 to ±18V	±10 to ±18V
Current, Quiescent		12mA	18mA	12mA	18mA	4mA	8mA	4mA	8mA
CASE		R	R	R	R	L	R	L	L
PRICE									
Low Pass/High Pass (1-9)		\$99/99	\$168/146	\$85/85	\$146/124	\$38/38	\$59/59	\$34/34	\$54/54
Low Pass/High Pass (10-24)		\$91/91	\$156/136	\$77/77	\$138/116	\$35/35	\$55/55	\$30/30	\$48/48

- NOTE: 1. Temperature — Operating, 0 to 70°C — Storage, -55°C to +125°C
 2. Max. allowable series input resistor to maintain f_c accuracy
 3. Offset adjustable to zero using external trim pot
 4. Output short circuit protected to ground
 5. Output noise, DC to 50kHz
 6. High Pass only

OUTLINE DIMENSIONS



*External trimpot (not included) 79PR1k, \$3.00 (1-9)

BAND PASS AND BAND REJECT RESPONSES

SPECIFICATIONS — (typical at 25°C unless otherwise noted)

FILTER TYPE	BAND PASS				BAND REJECT	
MODEL	715P1Q10	716P2Q5	717P1Q10	718P2Q5	719R1Q2	720R1Q2
CENTER FREQUENCY, f_o	STANDARD RANGE					
Range	1Hz to 10Hz		10Hz to 20kHz		1Hz to 10Hz	10Hz to 20kHz
Tolerance	±2%	±2%	±2%	±2%	±2%	±2%
No. of Pole Pairs	1	2	1	2	1	1
Stability vs. Temp. ¹	±.05%/°C	±.05%/°C	±.05%/°C	±.05%/°C	±.05%/°C	±.05%/°C
Source Resistance ²	20kΩ	20kΩ	20kΩ	20kΩ	20kΩ	20kΩ
PASSBAND GAIN	(0±.2)dB@ f_o	(0±.2)dB@ f_o	(0±.2)dB@ f_o	(0±.2)dB@ f_o	(0±.02)dB@DC	(0±.02)dB@DC
Freq. for ±0.1dB Gain Tol.	—	—	—	—	.2 f_o , 5 f_o	.2 f_o , 5 f_o
NOTCH, Attenuation @ f_o	—	—	—	—	-40dB	-40dB
SELECTIVITY, Q	10 ± 10%	5 ± 10%	10 ± 10%	5 ± 10%	2 ± 10%	2 ± 10%
ACTIVE CHARACTERISTICS						
INPUT (Non-Inverting)						
Input Impedance, min	1MΩ	1MΩ	1MΩ	1MΩ	1MΩ	1MΩ
Input Voltage Range, min	±10V	±10V	±10V	±10V	±10V	±10V
Input Bias Current, max	30nA	30nA	30nA	30nA	30nA	30nA
OUTPUT ⁴						
Rated Output @ 2mA	±10V	±10V	±10V	±10V	±10V	±10V
Full Power Response, min	—	—	—	—	50kHz	50kHz
Output Noise (RMS) ⁵	50μV	50μV	50μV	50μV	50μV	50μV
Output Resistance	1Ω	1Ω	1Ω	1Ω	1Ω	1Ω
Offset Voltage ³ @ 25°C	±2mV	±2mV	±2mV	±2mV	±2mV	±2mV
Offset vs. Temp. ¹	±20μV/°C	±30μV/°C	±20μV/°C	±30μV/°C	±20μV/°C	±20μV/°C
POWER SUPPLY (DC)						
Voltage, Rated Specs	±15V	±15V	±15V	±15V	±15V	±15V
Voltage, Operating, Specs	±10 to ±18V	±10 to ±18V	±10 to ±18V	±10 to ±18V	±10 to ±18V	±10 to ±18V
Current, Quiescent	10mA	15mA	10mA	15mA	10mA	15mA
CASE	L	R	L	L	L	L
PRICE						
(1-9)	\$42	\$62	\$38	\$57	\$42	\$38
(10-24)	\$38	\$56	\$34	\$50	\$38	\$34

- NOTE: 1. Temperature — Operating, 0 to 70°C — Storage, -55°C to +125°C
 2. Max. allowable series input resistor to maintain f_o accuracy
 3. Offset adjustable to zero using external trim pot
 4. Output short circuit protected to ground
 5. Output noise, DC to 50kHz

HOW TO ORDER

Each filter type in the table of specifications is identified by a catalog model number to which is added a frequency designation code at the time of order. For convenience, since the frequency may range from 0.001Hz to 20KHz, the letter A is used to represent the decimal and the letter K to represent the "thousands" comma. For example, 19,900 Hz is written 19K9Hz and 1.99 is written 1A99Hz. The following completed model numbers illustrate the technique.

710H2B-1A23($f_c=1.23$ Hz) High Pass Butterworth

718P2Q5-123($f_o=123$ Hz) Band Pass, Q of 5

700L4B-A00123 ($f_c = .00123$ Hz) Low Pass Butterworth

720R1Q2-1K23 ($f_c = 1230$ Hz) Band Reject

Since only a ±1% frequency tolerance is available for standard units, three consecutive digits are allowable in specifying a frequency between 0.001Hz and 20,000Hz. The 4-digit frequency 1.023Hz, for example, implies 0.1% accuracy, and will result in a phone call inquiring as to whether a special is desired.

IDEALIZED RESPONSE CURVES

- General Notes:
1. High pass filter responses are obtained as the mirror images of the equivalent low pass responses.
 2. Two attenuation scales are used to present greater detail around f_c .
 3. Normalized time = $1/\omega_c$; $\omega_c = 2\pi f_c$.

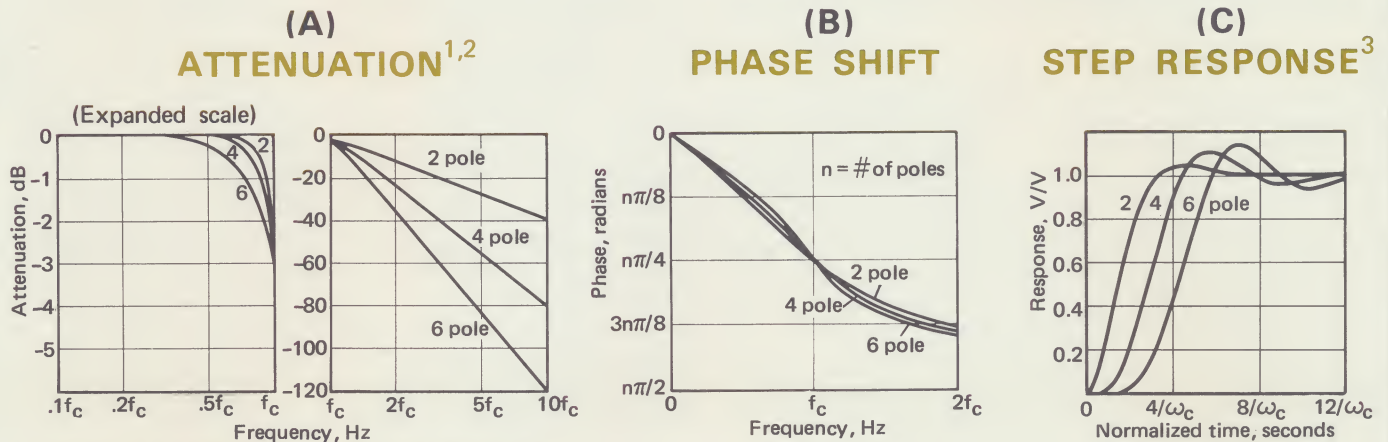


FIGURE 1 LOW PASS BUTTERWORTH

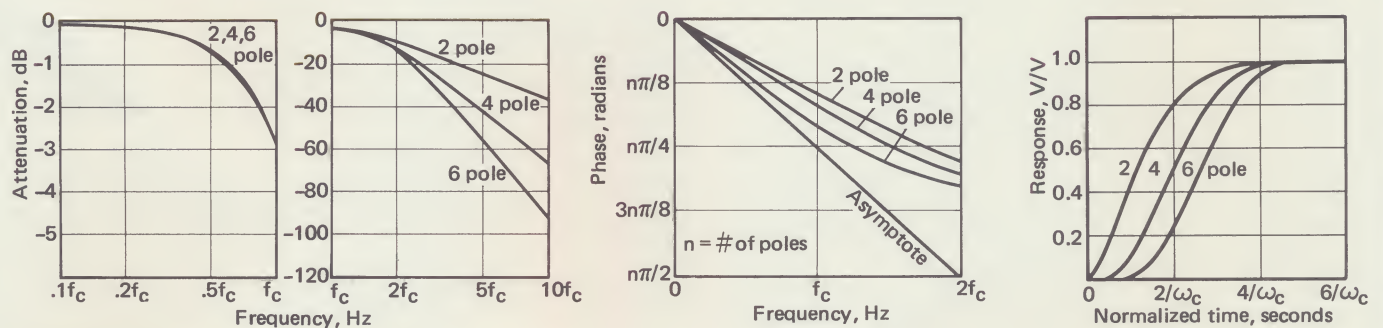


FIGURE 2 LOW PASS BESSEL

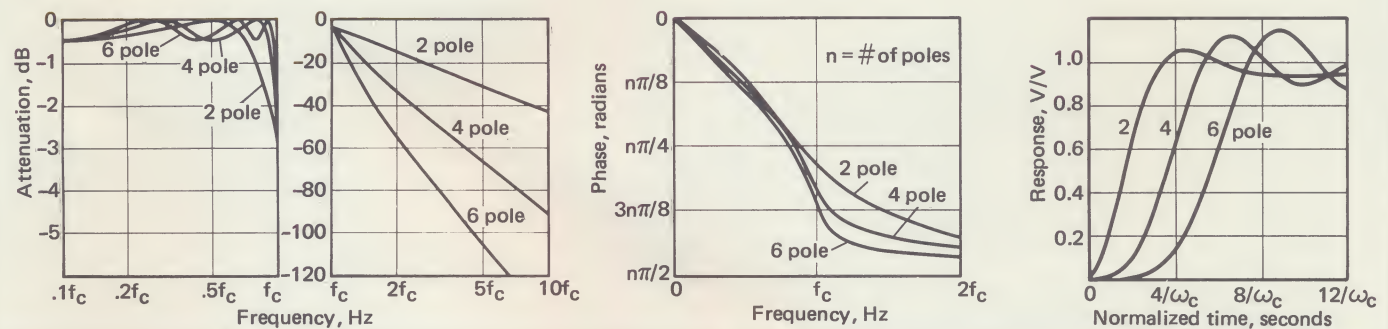


FIGURE 3 LOW PASS TCHEBYSCHIEFF, 0.5dB GAIN RIPPLE

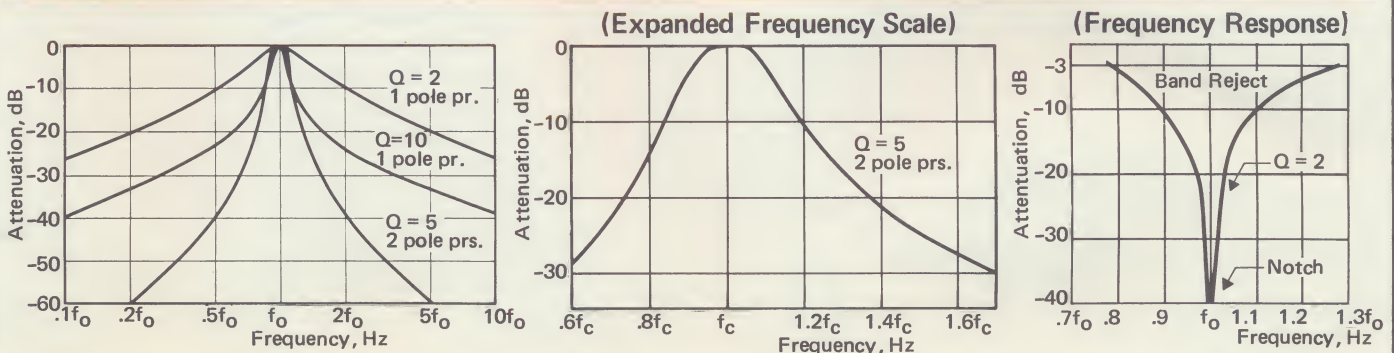


FIGURE 4A BANDPASS

FIGURE 4B BANDPASS

FIG. 4C BAND REJECT

CUSTOM FILTER DESIGNS

The standard line of active filters from Analog Devices includes products that have continued to meet customer requirements on a broad basis. However, Analog also recognizes the need to supply custom filter designs and will continue to provide this service as new applications appear for unique filter responses.

In addition to continuing its custom design service, Analog has initiated a new program to make available STANDARD SPECIALS. These are filter designs which have been developed and delivered to customers but are not yet listed in the catalog. This program offers to customers a specials capability uniquely featuring rapid delivery of filter products at substantial savings because they are not burdened with one-time engineering delays and related costs.

Several of the STANDARD SPECIALS designs now available at Analog are listed below and include low pass and high pass filters with Bessel and Tchebyscheff responses. See page 2 for technical information. They are readily available at low cost with specifications comparable to the standard Analog filter line. Also available are externally tunable filter designs which are customer adjustable over one frequency decade and are well suited for contiguous

comb filtering and for harmonic-noise analyzer applications or simply where one filter must be adjusted over a wide frequency range. The tunable technique offers a popular approach to reducing filter inventories inasmuch as one filter may be customer tuned to within $\pm 1\%$ over a decade of frequency.

In conjunction with the Pastoriza Division of Analog Devices, many filters have been developed for A to D and D to A computer interface applications. These designs are also available as part of the standard specials program. Please communicate your design needs to your Analog representative or contact us directly.

A partial list of custom features are:

Adjustable Gains:	To 40dB; external trim
Adjustable Frequency:	10:1 range, external trim
Composite Responses:	Cascaded characteristics
Special Responses:	1 to 8 pole transfer functions
Low Input Drift:	To $0.5\text{pA}/^\circ\text{C}$; to $0.25\mu\text{V}/^\circ\text{C}$
Phase Matched Filters:	To 0.5 degrees or phase locked designs for $\pm 0.1\%$ tracking
In/Out Configurations:	Differential, high current/voltage

ANALOG TO DIGITAL APPLICATION DESCRIPTION

Figure 5 shows a typical use of low pass active filters in a high speed multiplexed analog to digital conversion system. Outputs from each signal transducer are individually pre-filtered and fed to their respective multiplexer channel inputs. The selected multiplexer channel is connected to the input of a sample and hold module. The output of this sample and hold module normally follows its analog input. On receipt of a "hold" command, the output is held in steady state for the duration of each analog to digital (A/D) conversion. (The successive approximation A/D converter requires a non-varying input during conversion).

responses can be tailored to each transducer dynamic response characteristic for such reasons as: bandwidth extension, phase equalization, spurious response suppression, etc. 2. High frequency noise suppression. 3. Elimination of aliasing errors caused by high frequency noise. Aliasing errors originate when high frequency noise coupled into the signal circuit is modulated at the A/D conversion rate to produce a beat frequency falling within the normal signal frequency passband. This "alias" frequency then becomes indistinguishable from a signal frequency at the A/D converter output. High frequency noise of this type should therefore be attenuated before A/D conversion to prevent misinterpretation of the resulting digitized data.

ADVANTAGES

Prefiltering of each transducer output, prior to multiplexing, is useful for several reasons: 1. Individual filter

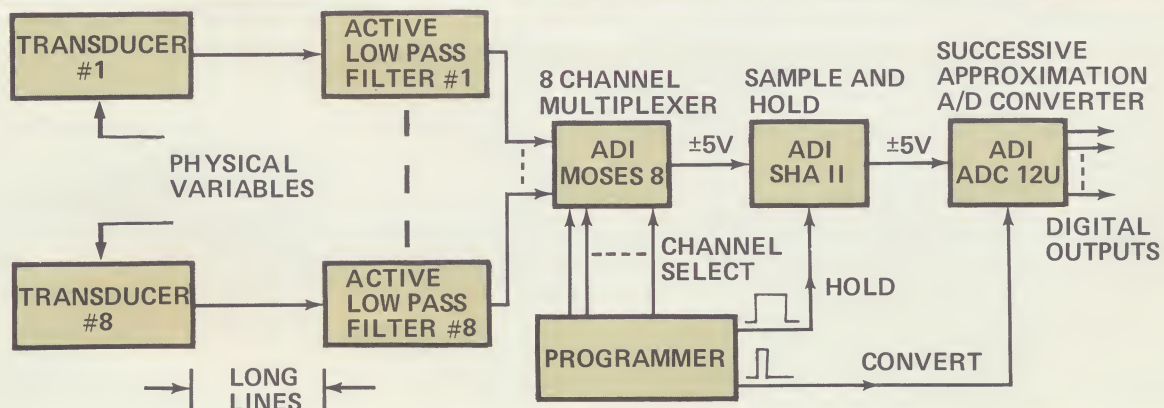


FIGURE 5 ACTIVE FILTERS USED IN MULTIPLEXED A/D CONVERSION SYSTEM